

## CASE REPORT

# Are Post-COVID-19 Sequelae a Challenge for Chest Wall Reconstruction in Flail Chest? A Case Report

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### ABSTRACT

**Background:** The SARS coronavirus-2 (SARS-CoV-2), responsible for COVID-19, with millions of infections that continue to accumulate, as well as the growing concern about chronic respiratory symptoms and changes in pulmonary fibrosis in recovered population. Rib fixation is indicated in patients with a flail chest who do not require mechanical ventilation, since they may develop chronic pain and thoracic deformity with a decrease in quality of life and incapacity for work. Selective mechanical ventilation with double-lumen tubes helps to collapse the lung on the side to be fixed, allowing the surgeon to preserve anatomical structures, making a better dissection.

**Case description:** A 60-year-old male, diabetic, history of COVID-19, previous 3 months, later depression; cyclist, fell on a retaining wall on 20th October 2020, assessed in a hospital where he was discharged from the emergency room with analgesics, without improvement, for which he went to the social security hospital where they found right rib fractures, monitored in the emergency room for 72 hours with poor analgesic response [Numeric Pain Intensity (NPI) 8–9/10], depending on oxygen at 5 L/min for SatO<sub>2</sub> = 90%. He was transferred to our hospital on 23rd October 2020, tomography with bilateral rib fractures (1°–9° right and 2°–5° left), right flail chest, bilateral pulmonary fibrosis (post-COVID-19), and right pleural effusion.

The third, fourth, fifth, sixth, seventh, eighth, and ninth right ribs with the StraCos system; it was impossible to perform surgery with right lung exclusion since, due to pulmonary fibrosis, the patient presented desaturations <80% with hemodynamic repercussions. He removed supplemental oxygen at 96 hours postoperatively and endopleural catheter at 7 days.

**Conclusion:** The SARS-CoV-2 infection has left many lessons, and a great way to discover; it has collapsed health systems and has also had a negative impact on the quality of care for the polytraumatization of the chest in the emergency room. We face real challenges when operating patients with unusual ventilatory parameters for trauma patients, with slow postoperative recovery, and increased costs.

**Keywords:** ARDS, COVID-19, Flail chest, Lung injury, Pulmonary fibrosis, Rib fixation, Rib fracture, SARS-CoV-2.

### RESUMEN

**Antecedentes:** el coronavirus SARS-CoV-2, responsable de la COVID-19, con millones de contagios que siguen acumulando, así como la creciente preocupación por síntomas respiratorios crónicos y cambios de fibrosis pulmonar en recuperados. La fijación costal tiene indicación en pacientes con tórax inestable que no requieren ventilación mecánica, ya que pueden desarrollar dolor crónico y deformidad torácica con disminución en calidad de vida e incapacidad laboral. La ventilación mecánica selectiva con tubos de doble lumen ayuda a colapsar el pulmón del lado a fijar, permitiendo al cirujano, preservar estructuras anatómicas, haciendo una mejor disección.

**Descripción del caso:** masculino de 60 años, diabético, antecedente de COVID-19, 3 meses previos, depresión posteriormente; ciclista, caída sobre muro de contención el día 20/10/2020, valorado en hospital donde le egresaron de urgencias con analgésicos, sin mejoría, por lo que acudió a hospital de seguridad social donde le encontraron fracturas costales derechas, vigilado en urgencias 72hrs con pobre respuesta analgésica (EVA 8–9/10), dependiendo de oxígeno a 5lt/min para SatO<sub>2</sub> = 90%. Solicitó alta voluntaria y traslado a nuestro hospital el día 23/10/2020, tomografía con fracturas costales bilaterales (1°–9°derechos y 2°–5°izquierdos), tórax inestable derecho, fibrosis pulmonar bilateral (Post-COVID-19) y derrame pleural derecho.

Se realizó fijación de arcos costales 3°, 4°, 5°, 6°, 7°, 8° y 9° con sistema StraCos; fue imposible realizar cirugía con exclusión pulmonar derecha ya que, por la fibrosis pulmonar, el paciente presentaba desaturaciones < 80% con repercusión hemodinámica. Retiro del oxígeno complementario a las 96 horas de postoperado y sonda endopleural a los 7 días.

**Conclusiones:** la infección por SARS-CoV-2 ha dejado muchas enseñanzas, y un gran camino por descubrir; ha colapsado sistemas de salud y también repercutido negativamente en calidad de atención al politraumatizado del tórax en urgencias. Enfrentamos verdaderos retos al operar pacientes con parámetros ventilatorios poco habituales para el paciente de trauma, con recuperación postoperatoria lenta, e incremento en costos.

**Keywords:** ARDS, COVID-19, Cofre mayal, lesión pulmonar, Fibrosis pulmonar, Fijación de costillas, Fractura de costillas, SARS-CoV-2.

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### BACKGROUND

The new SARS-CoV-2 coronavirus is highly contagious, and we are still learning about the disease, COVID-19; likewise, it is important to consider its possible long-term complications.<sup>1</sup>

Pulmonary fibrosis occurs in a wide range of clinical settings and can be associated with multiple etiologies. High-flow oxygen

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support can also cause it. Regardless of viral etiology, pulmonary fibrosis has been shown to develop after apparent recovery from infection. According to some authors, the SARS-CoV causes pulmonary fibrosis more frequently than other viruses.<sup>2</sup>

The gradual loss of lung function due to pulmonary interstitial fibrosis can have profound effects on the daily quality of life of people who were initially believed to have recovered from COVID-19.<sup>3</sup>

Patients with pulmonary fibrosis exhibit significant morbidity. There is evidence that ARDS lasting less than a week can lead to fibrosis. Therefore, severe cases leading to adult respiratory distress syndrome (ARDS) and those with prolonged recovery may be at increased risk for fibrosis rather than full recovery.<sup>1</sup>

Computed tomography plays an important role in diagnosis. Multiple studies have described short-term tomographic findings in patients infected with COVID-19, while few studies have investigated their long-term findings after discharge.<sup>4,5</sup>

Fibrous shadows, fibrous streaks, subpleural line, and traction bronchiectasis, with multiple lobes involved, were described as tomographic signs in the follow-up of COVID-19 patients. In a recent report, evidence of pulmonary fibrosis as a progression of SARS-CoV-2 infections was found on computed tomography in 42.9% of cases.<sup>2-5</sup>

On the contrary, the history of rib fixation appears from the beginning of the history of medicine with Soranus (78–117 AD) and 1500 years later with Ambroise Paré.<sup>6</sup>

Thoracic injuries account for 25% of mortality after trauma, and rib fractures are the most common type of injury. They occur in 20% of patients with chest trauma and are the most common injury after blunt trauma, responsible for long periods of inactivity from work, sometimes months, in turn occurring in 10–40% of hospital admissions. The number of fractured ribs is a marker of severity of the injury and as it increases, so does the morbidity and mortality.<sup>7,8</sup>

With more than six fractured arches, pulmonary and nonpulmonary complications can ensue and must be identified in a timely manner. The disequilibrium of the rib wall impairs spontaneous respiratory mechanics, which is exacerbated in the presence of pain.<sup>8</sup>

Therefore, a pivot in the treatment of these patients is pain control, which improves ventilatory mechanics.<sup>7,9</sup>

The number of fractured ribs is directly related to morbidity and mortality. Fligel et al. reported a mortality of 10% for patients with more than four fractured ribs, which increased to 34% in those with eight or more. In patients 45 years and older, with four or more fractured ribs, there is an increased risk of complications. Those aged 65 years and over with simple fractures had a five times higher risk of mortality than those under 65.<sup>8,10</sup>

In the past, it was observed that older adult patients had an increased risk of mortality, thoracic morbidity, pneumonia, and the need for nursing care at home. The population of elderly patients with rib fractures is increasing and the decision to fix them or not may be influenced by advanced age and associated pathologies.<sup>11</sup>

Given the complications associated with nonsurgical management, it is recommended to operate on older adults with significantly displaced rib fractures, as well as on those with multiple fractured ribs.<sup>8</sup> In Mexico, the government recognizes as older adult people aged 60 years and over.

In 2013, the consensus for the management of rib fractures was created to give indications for surgical management, emphasizing that the patient must be chosen well, not only meeting the criteria, but also making a correct evaluation.<sup>8</sup>

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Indications include a flail chest, symptomatic nonunion, and thoracotomy for other reasons, giving special consideration to less severe injuries with severe pain or poor lung function, with increased fixation in the nonunstable chest.<sup>11</sup>

In turn, the Chest Wall Injury Society was established in 2016, establishing the criteria to follow for rib fixation. The procedure itself results in immediate pain relief, allowing extubation the same day or the next in the case of mechanical ventilatory support.<sup>12</sup>

Tomography, in its 2D and 3D modalities, plays an important role in the diagnosis and planning of surgery, in the same way for postoperative follow-up.<sup>7,9,12</sup>

Currently, there are various systems for rib fixation. The StraCos system, made of titanium, is slim, maintains flexibility with respiratory movements, and has a low risk of system dysfunction due to overload.<sup>13</sup>

Of the two types of materials used for fixation, there is no difference, their objective is to achieve stability of the rib cage, which leads to improving ventilatory mechanics, healing the chest wall, and reducing pulmonary restriction associated with a chest wall deformity.<sup>8,14</sup>

Regarding the technique used for anesthesia, selective pulmonary ventilation is required, that is, pulmonary exclusion of the side to be operated on, using double-lumen devices that facilitate selective ventilation of the opposite lung. This provides a good surgical exposure of the affected side, facilitating the preservation of anatomical structures, making a better surgical dissection, while ensuring adequate gas exchange with the other and at the end of the procedure, this double-lumen tube is removed, leaving, if a conventional orotracheal tube is necessary.<sup>15-17</sup>

To date, there is no comprehensive study that broadly focuses on the incidence of complications associated with the fixation of rib fractures. Furthermore, there is not enough knowledge about the short- and long-term results after it, so it can be considered as a safe procedure with a considerably low risk of complications and satisfactory long-term results; complications related to surgery and implants are reported in approximately 10% of patients. However, the most clinically relevant complications, such as infections, occur infrequently, and the number requiring immediate (surgical) treatment is low.<sup>18</sup>

## CASE DESCRIPTION

This is the case of a 60-year-old male patient, diabetic on treatment. He has a history of having suffered COVID-19, 3 months prior to the trauma, which was managed with oxygen at home; likewise, it left him with post-COVID-19 depression in drug treatment, apparently controlled; road cyclist, who suffered a fall during training with blunt trauma to the right hemithorax on a road's retaining wall on 20th October 2020. His family members transferred him to a private hospital, due to right chest pain and dyspnea, wherein the evaluation in the emergency department they only performed a chest X-ray and reported the imaging study without evidence of injuries. No tomographic study was carried out.

The dyspnea increased, so he went to a social security hospital, and they found right rib fractures, with tomographic data of a flail

chest; he was monitored in the emergency room for 72 hours with poor analgesic response (NPI 8–9/10), depending on oxygen at 5 L/min to maintain oxygen saturation of 90%, he reported that breathing room air was less than 70%. It should be mentioned that this hospital was a COVID-19 hospital and in our city, we were at a maximum peak of infections and hospital saturation.

He was transferred to our hospital on 23rd October 2020, upon admission to the emergency department, he was found with mean arterial pressure of 81.33 mm Hg, HR 77x', RR 22x', eutermic, oxygen saturation 90% in semi-Fowler's position, with nasal tips at 3 L/min, 87% with room air; he reported NPI 9/10 chest pain, bilateral anterior, as well as right lateral and posterior, as well as pain when mobilizing the right upper limb with shoulder deformity. It was not possible to perform a spirometry test in the lab, but with the incentive spirometer he could only reach a volume less than 600 cc with very poor respiratory effort. The injury severity score (ISS) was scored in 16 (abbreviated injury scale (AIS)-90 = 4).

Multimodal analgesia with non-steroidal anti-inflammatory drugs (NSAIDs) and opioids was started before proceeding to the tomography in which bilateral rib fractures were found, with a nondisplaced fracture of the first right rib. The second, third, and fourth ribs with triple lines of fractures, anterior, lateral, and posterior, with displacement of the posterior line of the fourth rib. Lateral and posterior fractures of the fifth, sixth, seventh, and eight ribs, with significant intrusion mainly in the lateral lines. Ninth right rib with uncomplicated lateral fracture line. Were also found fracture of the second, third, fourth, and fifth left ribs, not displaced. Posterobasal atelectasis, generalized interstitial thickening with data suggestive of bilateral pulmonary fibrosis (post-COVID-19), and predominantly right bilateral pleural effusion. In addition, he was also diagnosed by imaging of the right acromioclavicular dislocation and ipsilateral scapula comminuted fracture with minimal displacement, which orthopedics gave nonoperative management.

Laboratories on admission with hemoglobin of 12 g/dL, 6,900 leukocytes with 75% neutrophils, 205,000 platelets, lactate of 0.75 mmol/L, glucose of 132 mg/dL, creatinine of 0.9 mg/dL, serum calcium of 8.3 mg/dL, creatinine phosphokinase of 3326 IU/L, arterial blood gas with pH 7.43, pCO<sub>2</sub> 40.5 mm Hg, pO<sub>2</sub> 56 mmHg, and SO<sub>2</sub> 90%.

It was proposed to perform reconstruction of the right chest wall by fixing the ribs with the StraCos system, which was performed on 24th October 2020 less than 24 hours after the patient was admitted. Originally the plan was to fix only the intruded fractures of the fourth, fifth, sixth, seventh, and eight right ribs.

With the patient in the left lateral decubitus position, and selective intubation with a double-lumen catheter for right pulmonary exclusion and through a 25-cm posteroanterior oblique incision with muscle sparing technique, fixation of the third, fourth, fifth, sixth, seventh, eighth, and ninth were fixed; due to instability when we were dissecting, the fixation of the third and ninth ribs was necessary; the STRACOS system was used; it was impossible to perform surgery with right lung exclusion since, due to pulmonary fibrosis the patient had desaturations <80% with hemodynamic repercussions; the lowest saturation recorded in the anesthesia sheet was 67%. Clotted hemothorax was drained and a Kardia Spiral 24fr catheter was placed in the endopleural cavity, as well as Blake 24fr drainage in the wall. Orotracheal extubation was achieved at the end of the procedure and he went to the recovery room with nasal tips at 2 L/min, saturating above 90%. Pain the next day after surgery was referred to by NPI 2/10, with multimodal analgesia with NSAIDs and opioids infusions in addition to topical

ropivacaine/lidocaine on the wound, resting, because the patient did not want to move.

The supplemental oxygen could be withdrawn 96 hours after surgery and the endopleural tube at 7 days, since there was an episode of exacerbation of depression on the third day after surgery that did not warrant modifying the medication, but during the 2 days that it had of approximate duration, the patient did not move out of bed or did his breathing exercises.

Another tomography was performed on 31st October 2020, which had more than 24 hours with an endopleural tube output of less than 100 mL/24 hours, with no evidence of a new effusion or pneumothorax, for which the tube was withdrawn, and the Blake-type drain. On 1st November 2020, an X-ray was performed without evidence of pneumothorax, so it was possible to discharge that day, with oxygen saturation greater than 93% when breathing room air and corrected rhabdomyolysis.

He returned to work 3 weeks after the surgery and to ride his bike, still with mild dyspnea, but with achieving the incentive spirometer volumes of 1200cc for 3 seconds at least. There was a new tomography on 24th December 2020, still with persistence of pulmonary fibrosis and he was discharged from the consultation.

There was a new review of the patient on this work, on 21st October 2021, a few days after the first year after the operation, and he commented that he fully returned to his life without difficulties, but he is still taking antidepressants.

## DISCUSSION

There is much to explore and understand about the long-lasting effects of severe viral respiratory infection and prevention of pulmonary fibrosis from COVID-19. The SARS-CoV-2 virus appears unique among coronaviruses due to its high transmission rate, atypical pattern of inflammatory response, range of severity of disease per infection, and distribution of those infected. It is unknown if COVID-19 will contribute to any long-lasting respiratory illness or symptoms. Almost 2 years into the pandemic, we continue to learn new things and are beginning to become aware of long-term complications, initially unknown.

Mortality rates have decreased since the start of this pandemic, suggesting that early detection, improved intervention, and the application of repurposed drugs are beginning to have a positive impact, although it is unknown whether this will translate into a decline of long-lasting effects on the lung or a decrease in the potential for fibrosis after infection.

All patients with COVID-19 pneumonia, regardless of gender, age, risk factors, and intubation or intensive care unit (ICU) stay, should undergo serial chest computed tomography and long-term follow-up for at least 1 year to assess residual damage. This may be particularly relevant in those with slow respiratory recovery and prolonged hospitalization. The prevalence of post-COVID-19 fibrosis is currently unclear.

The evolution of pulmonary fibrosis shows the potential for the lungs to continue to heal after being seriously injured.

On the contrary, the population of patients with rib fractures is increasing, especially due to the increase in transit mishaps and the decision to fix them or not, perhaps influenced by the age and comorbidities of the patient or by the limited bibliographic update of some health professionals, as well as ignorance of the indications to carry out the procedure.

In addition to the fact that the pandemic represented an overload for health institutions, some of which neglected other

pathologies because they focused on COVID-19. Even so, rib fixation has been shown to decrease mortality and complications.

Given the complications associated with nonsurgical management, it is recommended to operate on patients with flail chest, significantly displaced and/or multiple rib fractures. Not all fractures need to be treated surgically in the same patient. The patient should be chosen well, since the benefit of surgical management is to reduce complications, stay in a hospital ICU, use of mechanical ventilation, etc. Likewise, the importance of computed tomography in the diagnostic approach, surgical planning, and follow-up is emphasized.

The presence of pulmonary fibrosis secondary to the infection by the SARS-CoV-2 virus in this case represented a barrier to the management of the patient in the operating room, using the anesthetic technique selected to perform rib fixation, which resulted in a longer time surgery (210 minutes from skin to skin in this patient), in which hemodynamical stability of desaturation episodes was achieved, since great care had to be taken not to injure the lung with the instruments used to place the osteosynthesis material at the unable to collapse with selective intubation. In addition, another sequel of COVID-19, until that moment not considered, depression, was one more obstacle because there was no progress in what was originally planned for the postoperative period, due to the exacerbation episode during the hospital stay, since it was considered that being under drug treatment and in apparent control, it was not going to have any impact. The evolution was slow but finally satisfactory for the parties involved.

## CONCLUSION

The SARS-CoV-2 pandemic has had an impact on all aspects, health and economic. There is growing concern about chronic respiratory symptoms in addition to pulmonary fibrosis changes in recovered patients, but the sequelae observed in other organs and systems such as the central nervous, cardiovascular, and gastrointestinal systems, to mention some, should not be ignored.

Rib fixation is indicated in patients with flail chest who do not require mechanical ventilation, since they may develop chronic pain, increased risk of morbidities such as pneumonia, and chest deformity with decreased quality of life and work disability. Selective mechanical ventilation with double-lumen tubes helps to collapse the lung on the side to be fixed, allowing the surgeon to preserve the anatomical structures, making a better dissection, reducing the risk of pulmonary injuries, as well as a shorter duration of operative time, however, in the presence of underlying pulmonary pathology, it was disabled.

It is a fact that we continue to learn from this pandemic and more and more patients will have to attend to and present important sequelae.

The infection by the SARS-CoV-2 virus has left many lessons, and a great way to discover; it has collapsed health systems and has also had a negative impact on the quality of care for polytrauma to the chest in the emergency room. We face real challenges when operating patients with unusual ventilatory parameters for trauma patients, with a slow postoperative recovery, and therefore, increased costs of care.

## PATIENT CONSENT

The patient authorized the author and the PAJT to share his case by signing a consent form.

## REFERENCES

- McDonald LT. Healing after COVID-19: are survivors at risk for pulmonary fibrosis? *Am J Physiol Lung Cell Mol Physiol* 2021;320(2):L257–L265. DOI: 10.1152/ajplung.00238.2020. PMID: 33355522; PMCID: PMC7900916.
- Picchi G, Mari A, Ricciardi A, et al. Three cases of COVID-19 pneumonia in female patients in Italy who had pulmonary fibrosis on follow-up lung computed tomography imaging. *Am J Case Rep* 2020;21:e926921. DOI: 10.12659/AJCR.926921
- Wang F, Kream RM, Stefano GB. Long-term respiratory and neurological sequelae of COVID-19. *Med Sci Monit* 2020;26:e928996. DOI: 10.12659/MSM.928996. PMID: 33177481; PMCID: PMC7643287.
- Fang Y, Zhou J, Ding X, et al. Pulmonary fibrosis in critical ill patients recovered from COVID-19 pneumonia: preliminary experience. *Am J Emerg Med* 2020;38(10):2134–2138. DOI: 10.1016/j.ajem.2020.05.120. PMID: 33071084; PMCID: PMC7368908.
- Zhao Y, Wang D, Mei N, et al. Longitudinal radiological findings in patients with COVID-19 with different severities: from onset to long-term follow-up after discharge. *Front Med (Lausanne)* 2021;8:711435. DOI: 10.3389/fmed.2021.711435
- Nirula R, Diaz Jr JJ, Trunkey DD, et al. Rib fracture repair: indications, technical issues, and future directions. *World J Surg* 2009;33(1):14–22. DOI: 10.1007/s00268-008-9770-y. PMID: 18949513.
- de Moya M, Nirula R, Biffi W. Rib fixation: who, what, when? *Trauma Surg Acute Care Open* 2017;2(1):e000059. DOI: 10.1136/tsaco-2016-000059
- de Moya M, Bramos T, Agarwal S, et al. Pain as an indication for rib fixation: a bi-institutional pilot study. *J Trauma* 2011;71(6):1750–1754. DOI: 10.1097/TA.0b013e31823c85e9. PMID: 22182884.
- Perera TB, King KC. Flail chest. In: *StatPearls [Internet]*. Treasure Island (FL): StatPearls Publishing; 2020. PMID:30475563.
- Shiroff AM, Keating J, Milanez de Campos JR, et al. Surgical stabilization of rib fractures. *J Cardiothorac Trauma* 2019;4(1):41–47. DOI: 10.2106/JBJS.ST.19.00032
- Chan EG, Stefancin E, Cunha JD. Rib fixation following trauma: a cardiothoracic surgeon's perspective. *J Trauma Treat* 2016;5:4. DOI: 10.4172/2167-1222.1000339
- Hughes JD, Berning MJ, Hunt AL, et al. Rib fractures in geriatric patients: an observational study of surgical management. *J Cardiothorac Trauma* 2019;4(1):23–27. DOI: 10.4103/jctt.jctt\_9\_19
- Jayle CPM, Allain G, Ingrand P, et al. Flail chest in polytraumatized patients: surgical fixation using Stracos reduces ventilator time and hospital stay. *BioMed Res Int* 2015;2015:624723. DOI: 10.1155/2015/624723
- Winters BA. Older adults with traumatic rib fractures: an evidence-based approach to their care. *J Trauma Nurs* 2009;16(2):93–97. DOI: 10.1097/JTN.0b013e3181ac9201. PMID: 19543018.
- Langiano N, Fiorelli S, Deana C, et al. Airway management in anesthesia for thoracic surgery: a "real life" observational study. *J Thorac Dis* 2019;11(8):3257–3269. DOI: 10.21037/jtd.2019.08.57. PMID: 31559028; PMCID: PMC6753428.
- Meggiolaro KM, Wulf H, Feldmann C, et al. Atemwegsmanagement zur Seitentrennung der Lunge bei thorakalen Eingriffen: Ein Update [Airway management for lung separation in thoracic surgery: an update]. *Anaesthesist* 2018;67(8):555–567. DOI: 10.1007/s00101-018-0470-1. PMID: 30083992.
- Huerta MC, Villazón DO, Acevedo CA, et al. Ventilación mecánica selectiva (a un pulmón) y manejo anestésico en cirugía toracoscópica videoasistida. *Rev Mex Cir Endoscop* 2002;25(2):87–96.
- Peek J, Beks RB, Hietbrink F, et al. Complications and outcome after rib fracture fixation: a systematic review. *J Trauma Acute Care Surg* 2020;89(2):411–418. DOI: 10.1097/TA.0000000000002716